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UNITED STATES BUREAU OF MINES
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INFORMATION CIRCULAR

MINING METHODS AND COSTS AT PLANT C, ELIOT, CALIF., OF THE PACIFIC COAST AGGREGATES (INC.)

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MINING METHODS AND COSTS AT PLANT C, ELIOT, CALIF., OF THE PACIFIC COAST AGGREGATES (INC.)[1]

By Edward B. Kendall[2]

INTRODUCTION

This paper is one of a series being prepared for and published by the United States Bureau of Mines describing the methods of mining used and operating costs obtained in producing sand and gravel from deposits throughout the United States. This circular describes operations at the Eliot plant of the Pacific Coast Aggregates (Inc.), in Livermore Valley near San Francisco, Calif.

These papers are designed to disseminate technical information regarding the methods used. The cost tabulations represent local expenditures only and not total production costs. It is recognized that publication of total costs might in some instances cause embarrassment to individual producers as well as to the industry as a whole. On the other hand, operating costs are essential to the technical discussion and study of methods employed. The attention of the reader is specifically called to this differentiation in order that no misunderstanding of the scope of the cost tabulations shall ensue.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of A. Klenz, engineer, Pacific Coast Aggregates (Inc.), in the preparation of this paper.

HISTORY

The Pacific Coast Aggregates (Inc.) was formed by a merger in September, 1929, of the following companies, each of which owned and operated one or more plants in northern and central California:

The Associated Gravel Co.
The Coast Rock & Gravel Co.
The Pratt Building Material Co.
The Bay Development Co.
The California Rock Co.
The Rhodes-Jamieson Co.

Of the companies listed, the Bay Development Co. was the first to bring sand and gravel by barge to San Francisco. In the early years of the twentieth century aggregate requirements were simple and of small volume as compared with present-day needs. All pavements were made of natural cobblestones and the majority of the business and residential buildings were of frame construction. For more permanent edifices brick was used, and as a consequence the main market requirement was for sand for brick mortar.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6705."

[2] - One of the consulting engineers, U. S. Bureau of Mines, and vice-president and operating manager, Pacific Coast Aggregates (Inc.).

The greatest impetus to the building-material business came after the great fire of 1906 which razed almost the entire business section of San Francisco. The need of permanent and fire-resisting structures was forcibly impressed upon the populace of the devastated city, and as soon as the preliminary work of providing temporary housing was completed the builders turned to the task of rebuilding with permanent and fireproof materials. During the subsequent years the first plants producing concrete aggregates and other building materials at or near San Francisco were organized and built. Among the most prominent were the plants of Wm. Ford, Esq., and of the California Building Material Co., both at the town of Niles. (See fig. 1.)

A large alluvial cone of gravel, built up from the watershed of surrounding foothills by Alameda Creek, constituted the raw-material reserve. Excavation was carried out variously by steam shovel, slack-line cable, and electric drag-line excavators. The deposits of the California Building Material Co. have been entirely depleted and their plant salvaged, but the Wm. Ford plant is still in operation, although it is now owned by the Pacific Coast Aggregates (Inc.). An estimated total of 12 million tons has been removed by these plants, the majority of which material has been used in building and street construction in the bay area. While the Pacific Coast Aggregates (Inc.) own extensive deposits estimated to contain 20 million tons, its main operating plants at present are located in the Livermore Valley. As these latter plants are more representative of present-day practices in aggregate production, this location has been chosen for description.

GEOLOGY

Before the disturbance that changed the geography of the coast valleys and created the break in the coast line now known as the Golden Gate, the Livermore Valley was an inland basin not directly connected with the ocean. The lifting of the valley floor left an alluvial plain 3 miles in average width and about 12 miles long through which flowed a system of creeks the largest of which is the Arroyo del Valle de San Jose. This creek, which drains the local watershed of the Coast Range, flows from east to west along the southern edge of the valley. As the slope of the valley is very flat (less than 0.5 per cent), the creek at times of flood after torrential rains spreads out over the entire area of the basin. Season after season it carried the gravel, sand, and bowlders from the erosion of the rocky canyons above and deposited its burden in the flat basin. Prospecting and well drill holes throughout the valley bear out this theory, as they invariably show gravel to a depth of 200 to 300 feet.

The land holdings of the Pacific Coast Aggregates (Inc.) extend along the present stream bed for about 2 miles and comprise about 670 acres owned in fee and 230 acres of leaseholds.

Present excavations are carried to a maximum depth of 60 feet. While well drill holes show gravel deposits to a depth of 200 to 300 feet, the holdings of the company are so extensive that, until depletion becomes a factor to be considered, excavation will be limited to 60 feet. Also, in order to produce a well-graded product within the range of present-day specifications, the inclusion of material from greater depth would prove unprofitable inasmuch as it contains a greater percentage of large bowlders and less fines than material nearer the surface. The intrusion of clay strata of varying thickness would also cause additional expense in washing, which is already a considerable item in the total cost.

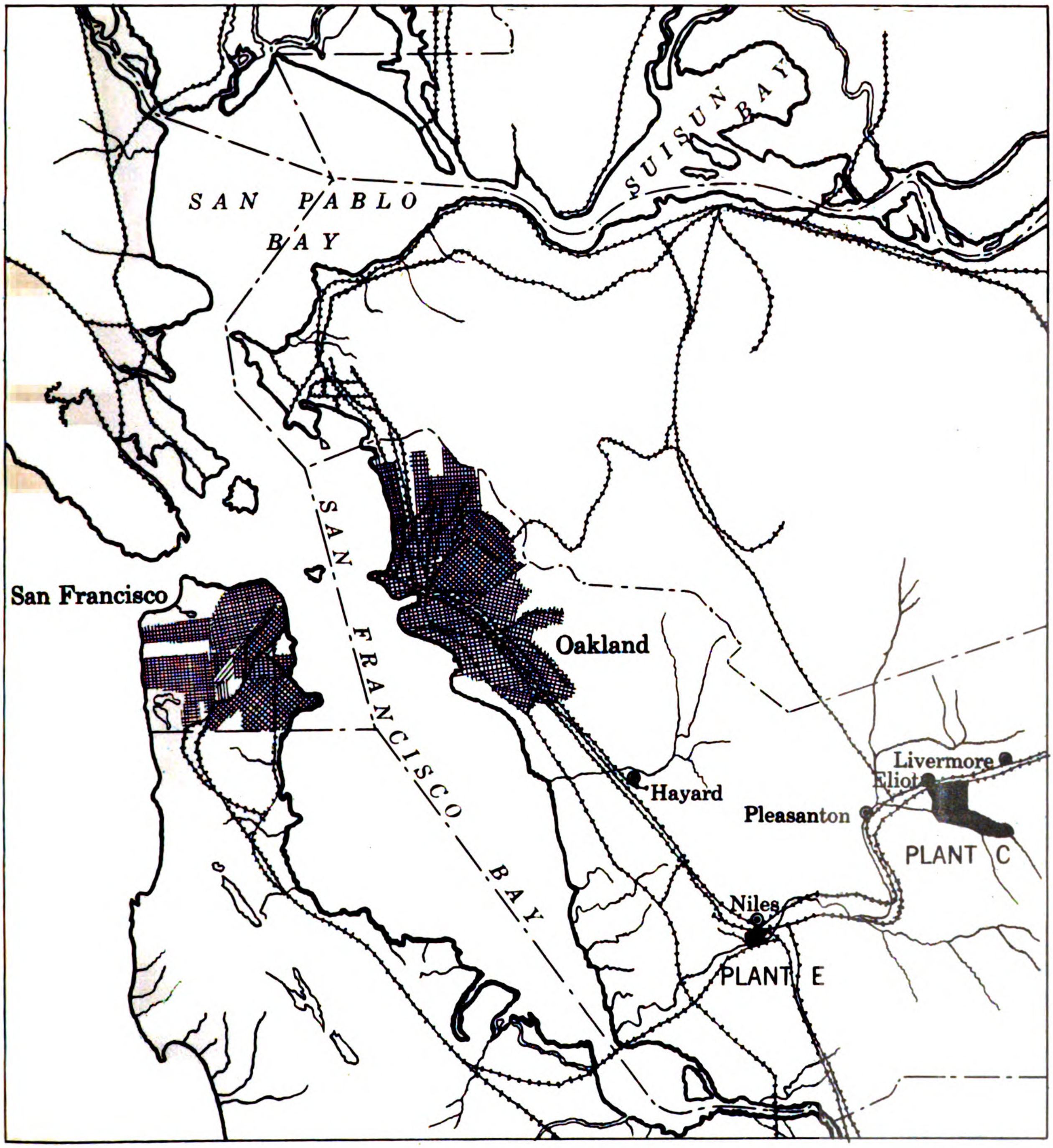


Figure 1.— Map of San Francisco Bay region, showing location of plants C and E

The overburden, where it occurs, is negligible and readily disposed of by washing, so that stripping operations are unnecessary. The gravels consist of a mixture of the rocks prevalent in the Coast Range, among which serpentine, basalt, quartz, and sandstone predominate. The gravels are sound, being formed from the harder rocks that have best withstood the disintegrating forces of nature. In tests made for the suitability of aggregates for the various purposes delineated in specifications of State highway commissions and consulting engineers for private enterprises, these gravels are satisfactory.

The great uniformity of the deposit coupled with the logs of wells in the immediate vicinity of the deposits has made it unnecessary to do any prospecting, and excavations are carried to within a safe distance of the boundary line of the properties, leaving just enough berm to prevent destruction of line fences. Thus it has been possible to determine closely the extent and approximate tonnage of raw material in the deposit.

The gravel is well graded from sand to bowlders 14 to 16 inches in diameter. Few pieces exceed this size, as the natural classifying action of water flowing with diminishing velocity has deposited the larger sizes further upstream.

A screen analysis of pit-run material is as follows:

Retained on	Passing	Per cent
3-inch opening		20
1½ do.	3-inch opening	15
¾ do.	1½ do.	15
⅜ do.	¾ do.	15
-	⅜ do.	35

This analysis is an approximate average and will vary considerably from time to time according to the location of the shovel in the pit.

Of the plants located in the Livermore Valley the most representative as well as the largest shipping unit is Plant C at Eliot, on the Southern Pacific Railroad, and this is described in detail; immediately adjoining this are also plants A and D which are working under virtually the same conditions and in the same kind of material.

EXCAVATION

Originally plant C was designed for operation by slack-line cable excavator and was worked in this manner for about three years. The slack-line operation was arranged and equipped as follows: A tmiber tower having a height of 120 feet to its head sheaves was erected on the bank of Arroyo del Valle. On a turntable platform at a height of about 100 feet was a 300-hp. electric hoist directly connected to a variable-speed, slip-ring motor. This hoist was equipped with an air-controlled band friction drive and had two speeds, 250 feet per minute for digging and 1,000 feet per minute for traveling. A 150-hp., direct-connected electric hoist also on this platform had one drum and one speed and was used for operating the slack-line cables. Two 1⅜-inch, type B, flattened-strand, plow-steel cables with an 800-foot span were placed over the two 60-inch head sheaves. One end was fastened, with equalizer block interposed, to a deadman on the opposite side of the pit, and the other to a so-called "follower block" composed of two special-design, steel sheave blocks reaved with seven parts of 1-inch wire rope. The free end of the reaved rope led to the 150-hp. take-up hoist already described. The follower block was anchored to the ground. A 4-cubic yard, special-design, forward-dumping bucket hung from trolleys traveling on the slack-line. The dumping was automatic and accomplished by a fixed stop block fastened to the sky line.

One operator stationed in the hoist room at an elevation of 110 feet in the tower controlled both hoists and had a clear view of the bucket at all times.

Excavation was carried to a depth of 60 feet, and as the water table for this region is close to the surface of the creek bed the pit was full of water at all times. With this type of excavation and with the span limited to an 800-foot radius it is only a matter of time until the material within reach will be depleted unless replenishment restores the pit. As this replenishment did not materialize in the three years during which the slack-line excavator operated, it became necessary either to move the primary plant to a new location or to employ some other method of recovery. In order to avoid a repetition of this dilemma it was decided to abandon the slack-line method in favor of the shovel type of operation which is now in use.

Under the present method of operation the digging is done in an open pit with a level floor. The present maximum working face is about 25 feet high and straight-line thoroughcuts are made wherever possible. Figure 2 shows the layout of the pit and the haulage tracks.

The shovel is an 80B, full-circle, electric shovel, mounted on caterpillar traction and fitted with a 3-cubic yard dipper.

The current for use on the shovel is transmitted at 2,200 volts from transformers located at the plant and is stepped down at the shovel to 440 volts A.C. which is used in all the motors.

The shovel is equipped with two control boards and the following 3-phase, 60-cycle motors:

	Horsepower	R.p.m.
Main-hoist motor..	165	680
Swing motor...........	50	690
Crowding motor......	50	690
Bucket-trip motor	3	1735
Compressor motor..	3	
Total.............	271	

HAULAGE

The shovel loads directly into 30-cubic yard, standard-gage, steel cars. A 40-ton, saddle-tank, steam locomotive hauls the gravel from the shovel to the dump hopper at the plant a distance of about 1,500 feet. The track is laid on a grade not exceeding 2½ per cent. The cars hauling material from the pit have the following specifications:

Gage.......................	56-1/2 inches
Length over all..	39 feet 3 inches
Width over all....	10 feet 4 inches
Wheels....................	8 - 33 inches diameter, 725 pounds
Journals...............	8 - 5-1/2 by 10 inches
Twin vertical cylinders for air dump	

The cars are of the automatic air-dump type and are controlled from the locomotive cab through an air-hose connection to a compressor set mounted on the locomotive. This enables the driver to dump the cars without leaving the cab. The cars are spotted on a trestle over the dump pit shown in Figure 3.

A reinforced-concrete conveyor tunnel extends under the full length of the pit and five 24-inch feed gates are distributed along the roof of the tunnel. A surge storage of about

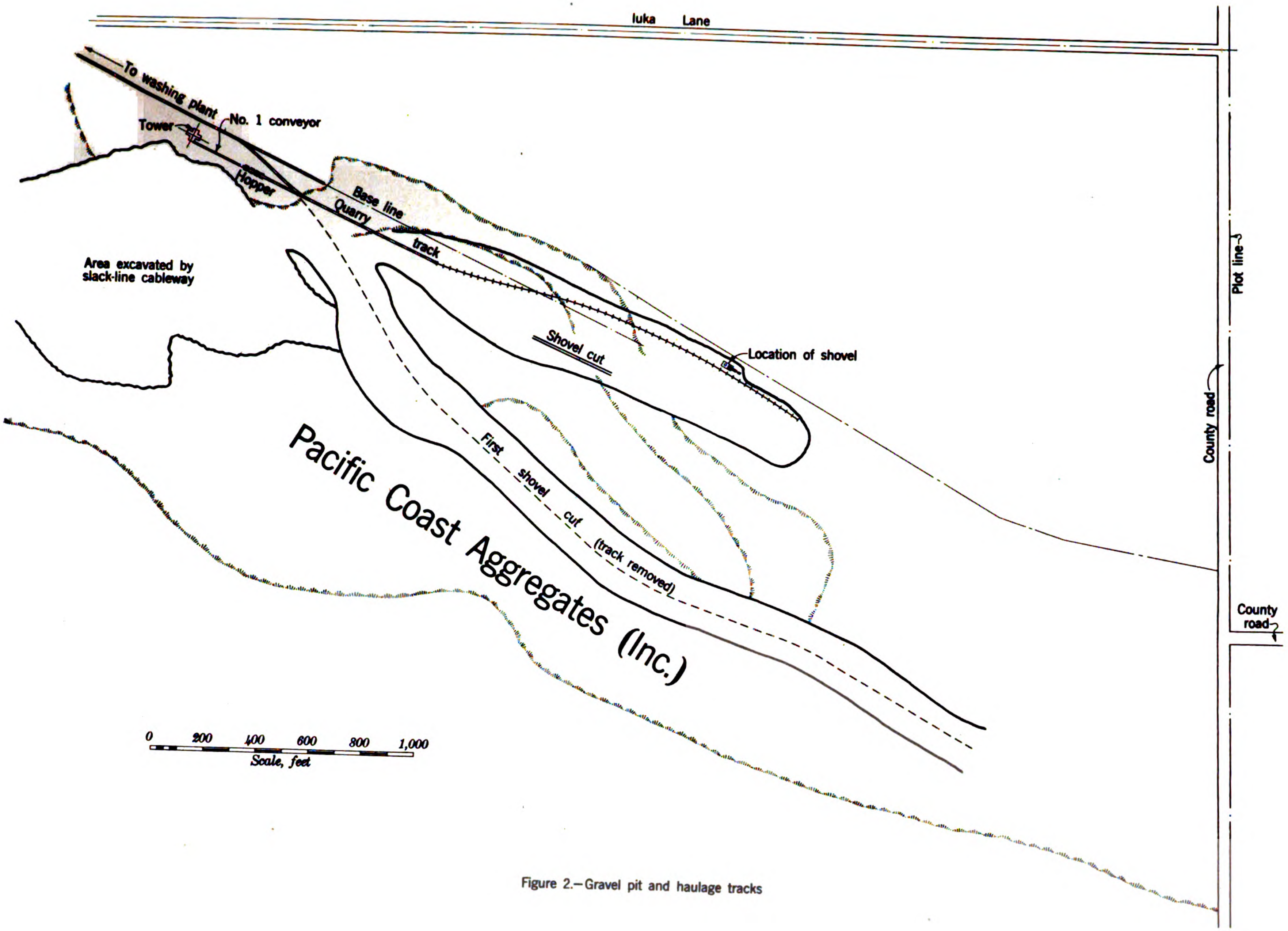


Figure 2.—Gravel pit and haulage tracks

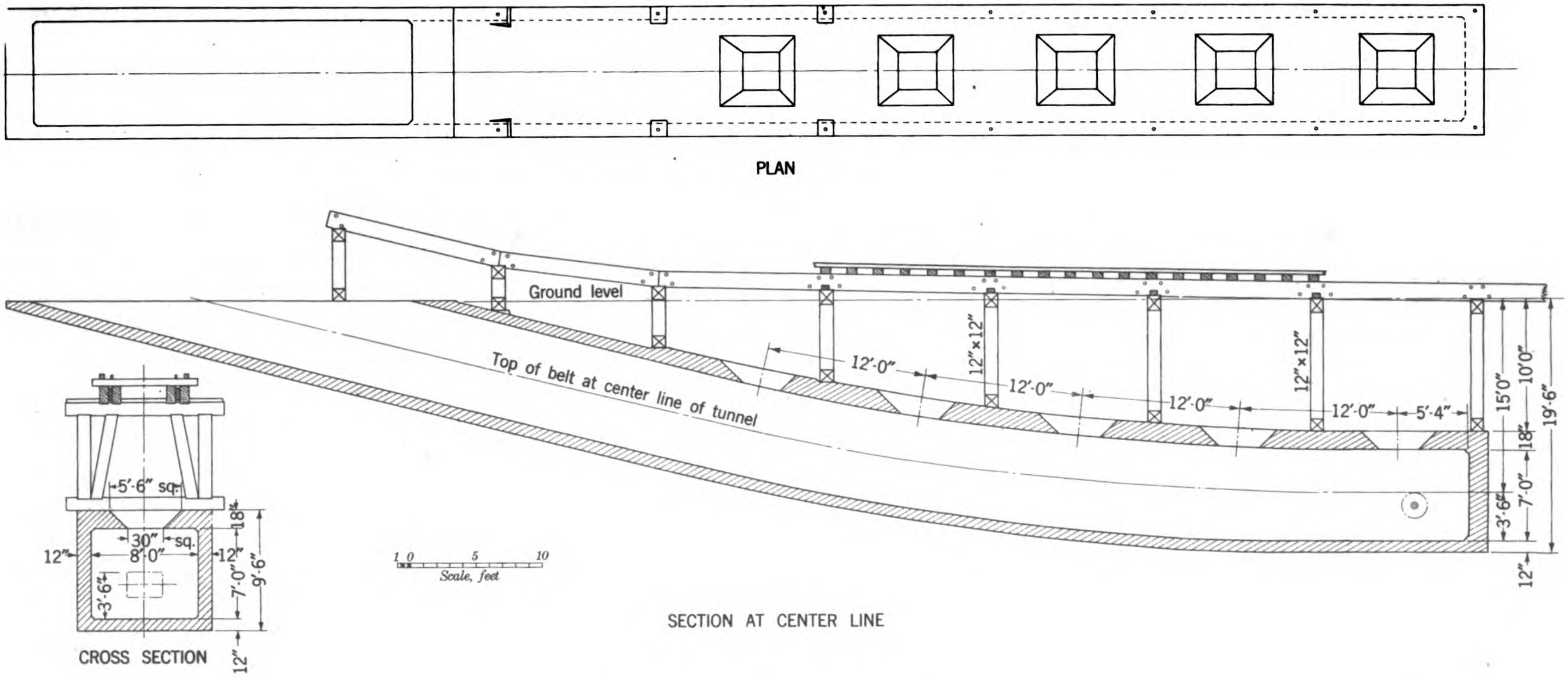


Figure 3.—Dump pit, conveyor, and trestle

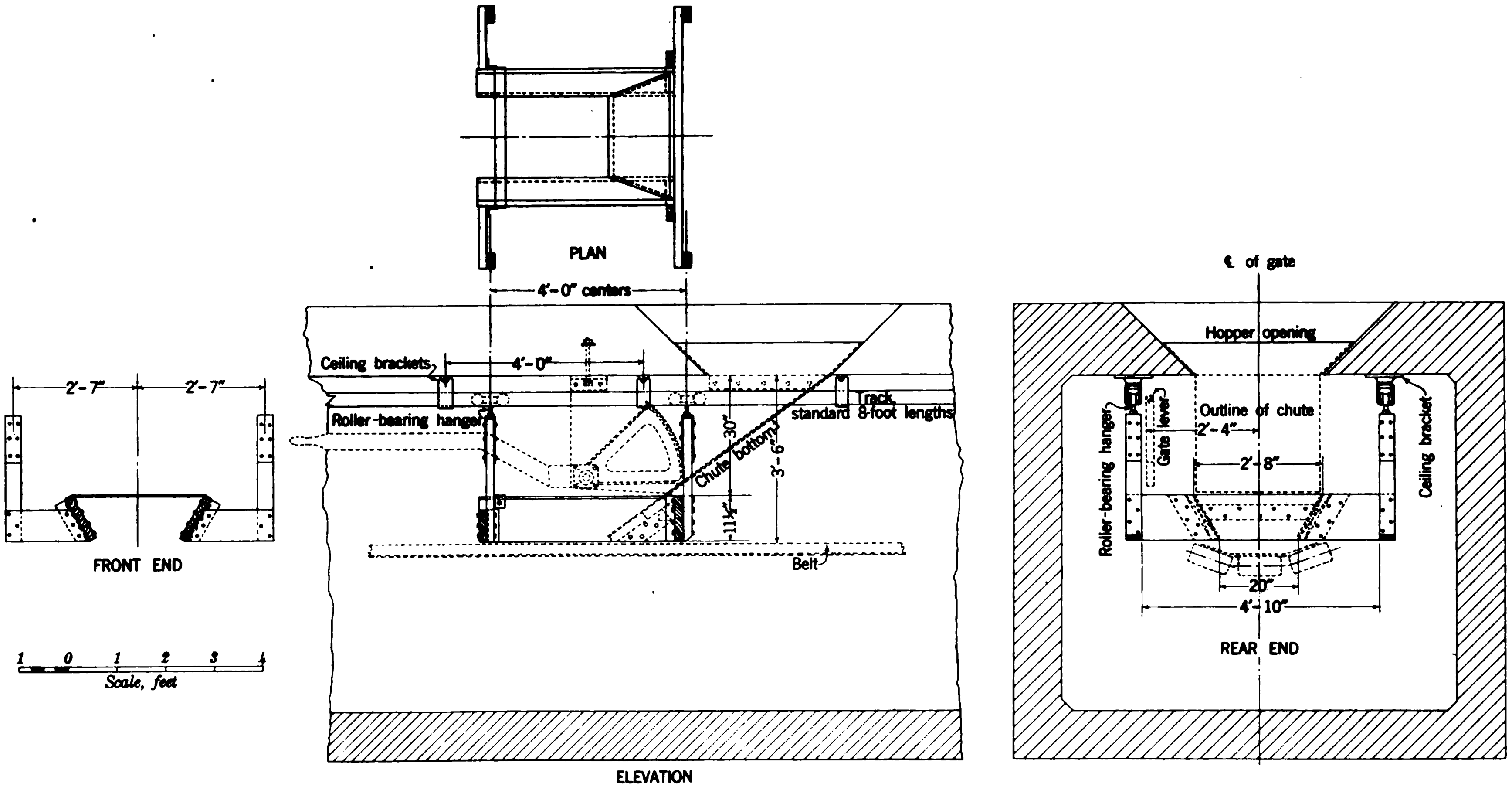
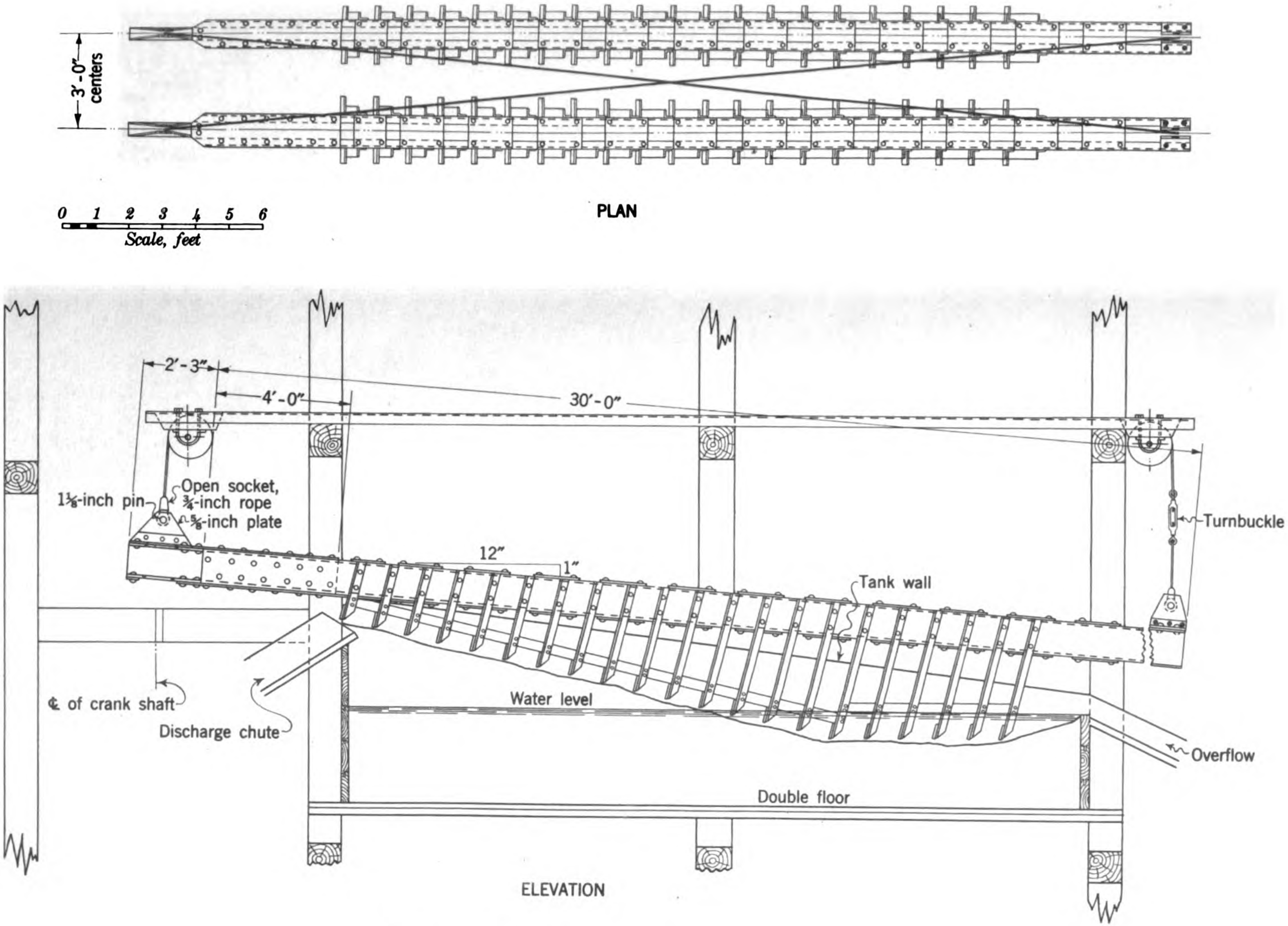


Figure 4.—Movable hopper for loading belt from car hopper


PLAN

ELEVATION

Figure 5.—Reciprocating balanced rake washer

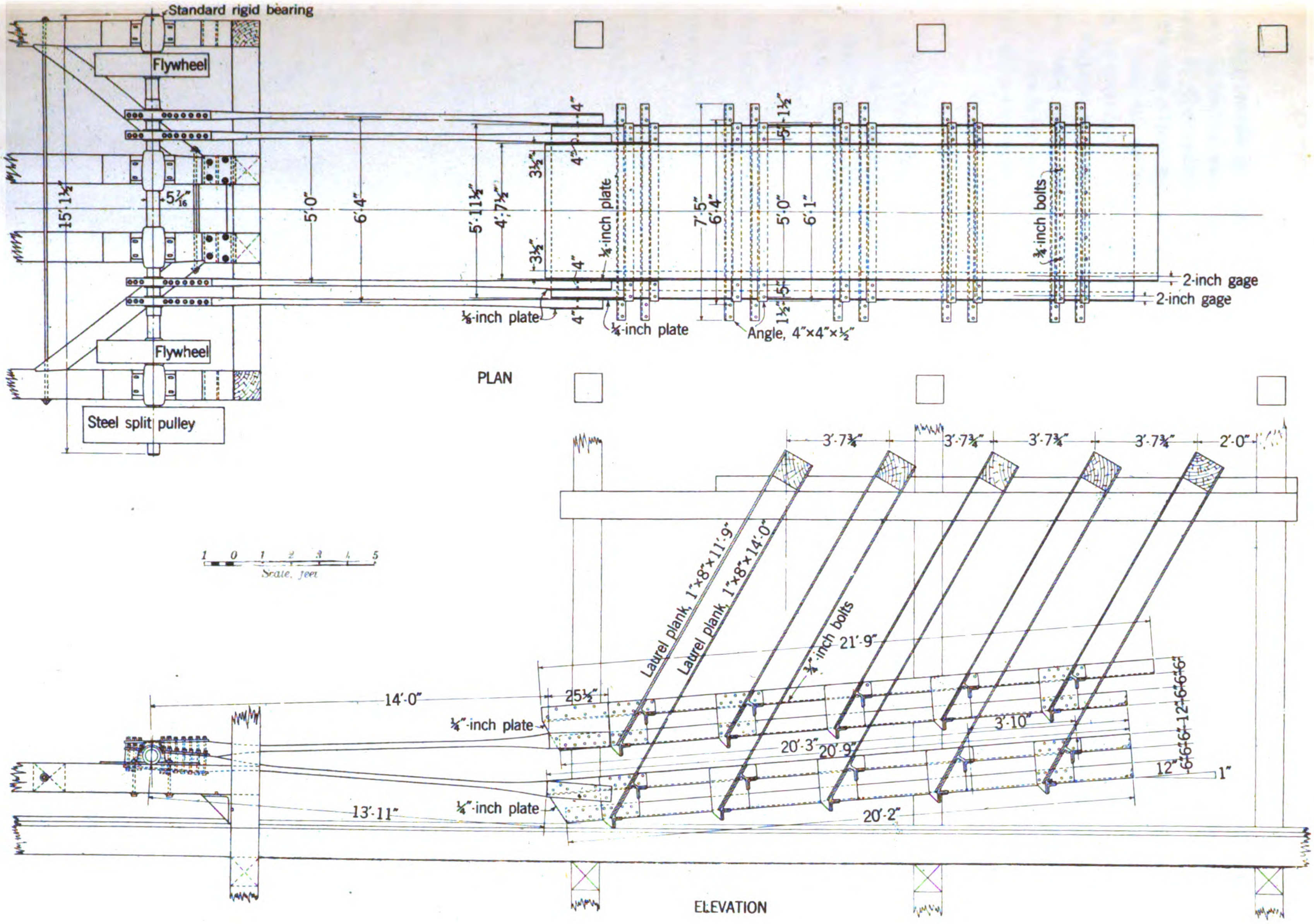


Figure 6.–Four-deck shaker screen

150 cubic yards of pit-run material is maintained in the dump pit and the feederman is enabled, by using successive gates, to keep the plant running during short shutdowns of either shovel or transportation equipment for moving track or for minor repairs. Hand feed control by the man stationed at this point has been found more satisfactory than any mechanical devices such as apron or reciprocating feeders; the judgment of an experienced man for this duty is vital to a steady flow of material through the plant.

Figure 4 shows the details of the traveling hopper running on roller-bearing trucks on a track hung from the tunnel ceiling; this arrangement enables the pit-man to move from one gate to another as the need arises. The chutes and quadrant gates shown by dotted lines are fixed at each opening to the hopper above.

WASHING AND SCREENING PLANT

A 30-inch, 7-ply, rubber-covered conveyor belt operating horizontally and up an incline of 18° takes the raw material from the dump hopper to the primary mill. This belt is 200 feet between centers and has a 3/16-inch rubber top and 3/32-inch bottom and a life of 750,000 tons. The drive is a 50-hp. motor directly connected through a tandem drive set on the ground level.

The conveyor delivers to a scrubber and scalping screen of heavy construction developed in western gold-dredge practice. The trommel is of the trunnion type, 72 inches in diameter by 30 feet long. The shell is made of 3/8-inch plate with 5/8-inch and 2 3/4-inch round punched openings. The trunnion rollers are 30 inches in diameter and have 10-inch faces. The washer is driven at 10 r.p.m. by a 60-hp. motor through a belt and countershaft to the geared rear trunnions.

About 800 gallons of water per minute is supplied by nozzles inside the revolving scrubber.

All material rejected on the 2 3/4-inch openings passes by gravity through framed open chutes lined with steel plate to two gyratory crushers. The minimum slope of chutes is 9 inches per foot.

The gyratory crushers have feed openings of 12 by 88 inches and discharge openings of about 2 inches. Their capacity is about 35 tons per hour each at this setting. Each crusher is driven at 525 r.p.m. by a 60-hp., 1,200-r.p.m. motor belted to the drive pulley of the crusher.

All material which passes the openings of the scalper screen drops to a reciprocating washer mounted directly below the scalper. Figure 5 shows a plan and elevation of the washer which consists of two balanced rakes inclined at 1 inch to the foot and driven through a crank shaft rigidly connected at the upper end and belted to the countershaft common to both scalper and washer. This shaft is driven by a 60-hp. motor. The washer, 30 feet long and 6 feet wide, was designed by the company's engineering department. It operates at 30 r.p.m. and functions as a dewaterer as well as a washer.

A 30-inch, rubber-covered conveyor belts 225 feet center to centers takes material from the washer and delivers it to the top of the screen house at an elevation of 80 feet above ground level. The speed of this belt is 250 feet per minute.

The conveyor discharges directly on to the top deck of a shaker screen having four decks 6 by 20 feet long. The perforations of these screens vary as market requirements dictate but they are usually 2-1/4, 1-3/4, 1-1/4 and 1/4 inches in diameter.

Figure 6 shows a plan and elevation of the screen as designed and built by the company. The screen is set on a slope of 1 inch to the foot and is driven at 140 r.p.m. from a crank shaft having a 4-inch throw. Power is furnished by a 40-hp., 440-volt motor running at the rate of 690 r.p.m. and belted to the crank shaft. Wash water at the rate of 1,000 gallons per minute is supplied to this screen. The material rejected over the three top decks is chuted directly to 12 by 15 by 50 foot bins below the screens. The product passing through the 1/4-inch bottom deck, together with the large volume of wash water used on this screen, is flumed to two 8-foot diameter sand wheels which classify and dewater the sand in two grades before it is chuted to storage bins below. These sand wheels, of a type developed and built by the company's engineering department, are 8 feet in diameter and have 36-inch flights. They are driven through open-type, double spur-gear speed reducers belted to separate 10-hp., 720-r.p.m. motors. The overflow water is discharged into a sand-settling tank equipped with manganese-steel chain and flights running at a speed of 15 feet per minute. The drive is a 7 1/2-hp. motor, operating through open spur-gear reduction. Figure 7 shows details of the drag. The dewatered fine sand is used mainly for asphalt sand and is discharged into a 100-ton steel bin of self-cleaning cone type.

The products of the shaker screen passing 1 1/4-inch and rejected on 1/4-inch round perforations are conveyed to a fine-screening plant where three single-deck shaking screens (fig. 8) having 6 by 10 foot decks classify material on 3/4, 1/2, and 1/4 inch perforations. These products are made under a generous spray of wash water (400 gallons per minute) and the material passing the 1/4-inch perforations together with the water is sent through open-box, steel-lined flumes to the sand wheels, while the sized material is chuted to bins below the screening plant.

The conveyor to the fine screening plant has an 18-inch, 4-ply, rubber belt 80 feet between centers, running 200 feet per minute over a path at first horizontal and then inclined at 18°. The power used is about 7-1/2 hp., taken by spur-gear reduction and belt from a countershaft driven by a 25-hp. motor which also drives the three screens.

The crushed material produced by the two gyratory crushers is dropped by a chute to the foot of a belt-and-bucket elevator having buckets of the continuous type 17 inches by 9 inches in size. The belt is 8-ply, 18 inches wide, and has a 1/8 and 1/16 inch rubber cover. The elevator is inclined at 60° from the horizontal, is 65 feet between centers, and operates at a speed of 180 feet per minute.

The elevator discharges to a heavy, 5 by 22 foot trunnion-type revolving trommel driven at 11 r.p.m. by a 25-hp. motor by bevel gear through a speed reducer. The screen is set on a slope of 1/4 inch to the foot and is in three sections having 1-1/2, 1-1/4, and 3/4 inch round perforations. The crushed rock is washed on the screen and the rejected material is chuted to 10 by 12 by 30 foot bins of solid cribbed-timber construction on concrete footing walls. The contents of the bins rest on the ground.

Material passing the 3/4-inch openings is chuted to a double-deck, 3 by 6 foot vibrating screen. The upper deck has 1/2-inch and the lower deck 1/4-inch openings. The screen is of the spring-suspended type and uses the unbalanced-pulley principle for its vibration.

Material passing the 1/4-inch screen falls to a 3 by 6 foot vibrating screen having 1/8-inch square openings and a slope adjustable from 28° to 32°. This screen has a cam and striker action. The screen cloth is rigidly fastened to the frame and is vibrated by a rigid post connection to the center of the screen. It has small capacity and is not efficient when overloaded. The product passing 1/8-inch mesh together with the wash water is flumed back to the reciprocating washer in the primary plant where it is dewatered with the natural sand and sent to the gravel screening plant.

A set of 42 by 16 inch rolls set close and a 48-inch disk crusher are so located (see flow sheet, fig. 9) that rejects from both the crushed rock and gravel screening plants may be returned for recrushing.

The rolls are of a special high-carbon steel and are driven by belt from a 50-hp., 440-volt motor operating at 720 r.p.m.

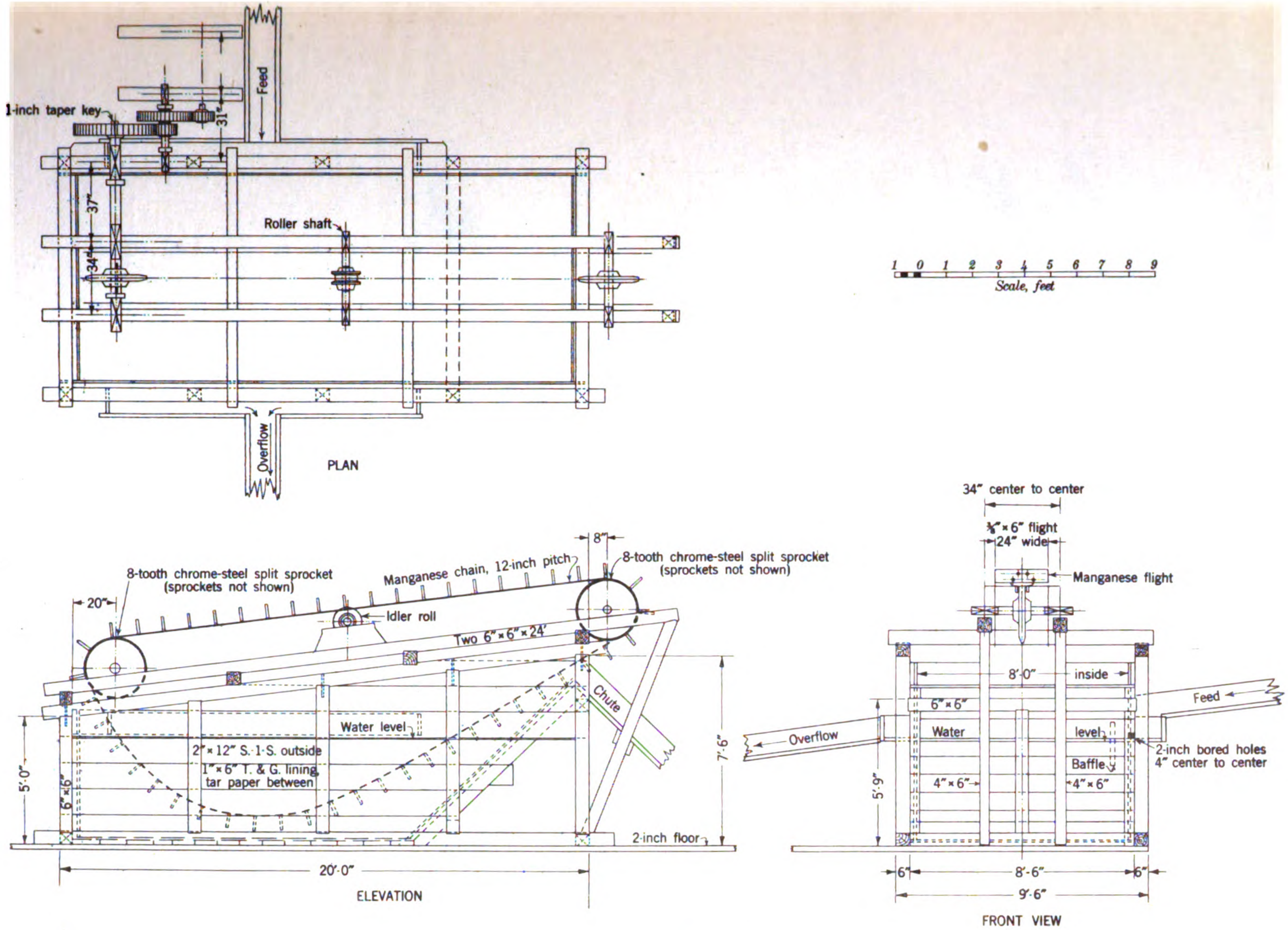


Figure 7.—Asphalt sand settler and drag

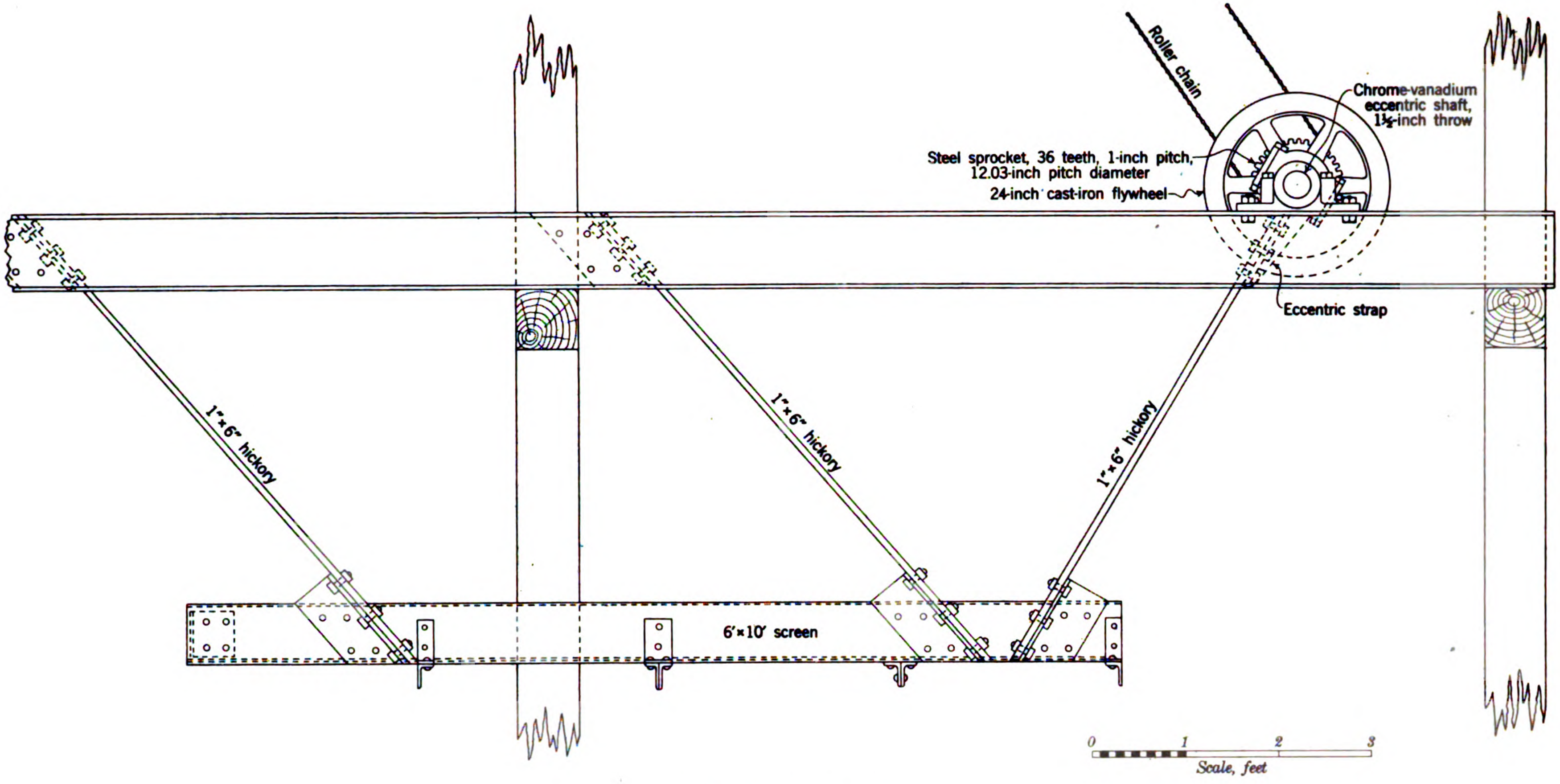

Roller chain
Chrome-vanadium eccentric shaft, 1½-inch throw
Steel sprocket, 36 teeth, 1-inch pitch, 12.03-inch pitch diameter
24-inch cast-iron flywheel
Eccentric strap
1"×6" hickory
1"×6" hickory
1"×6" hickory
6'×10' screen
0
1
2
3
Scale, feet

Figure 8.—Single-deck shaker screen

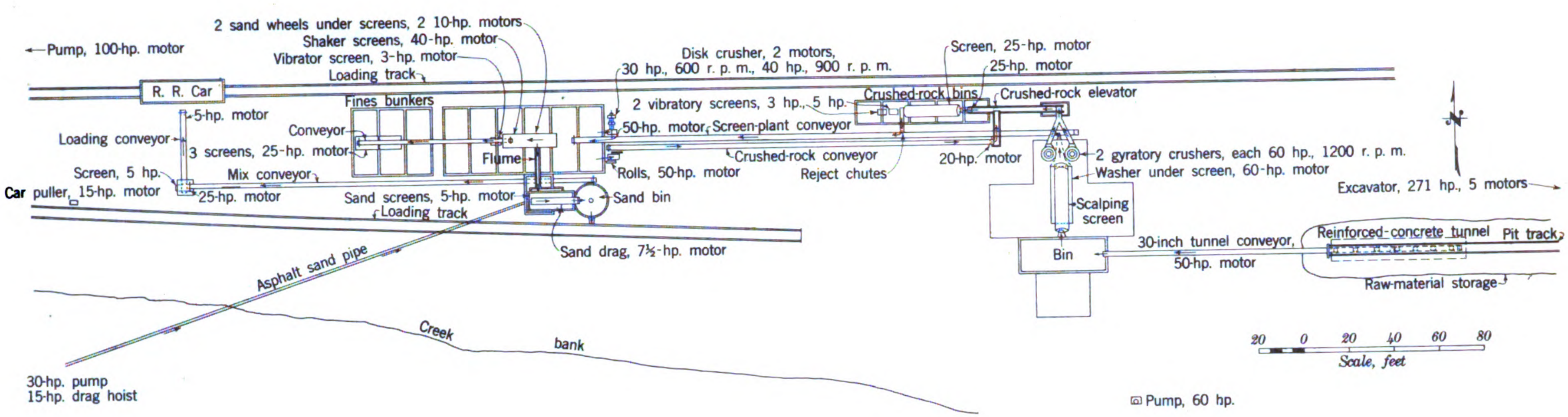


Figure 9.—Flow sheet

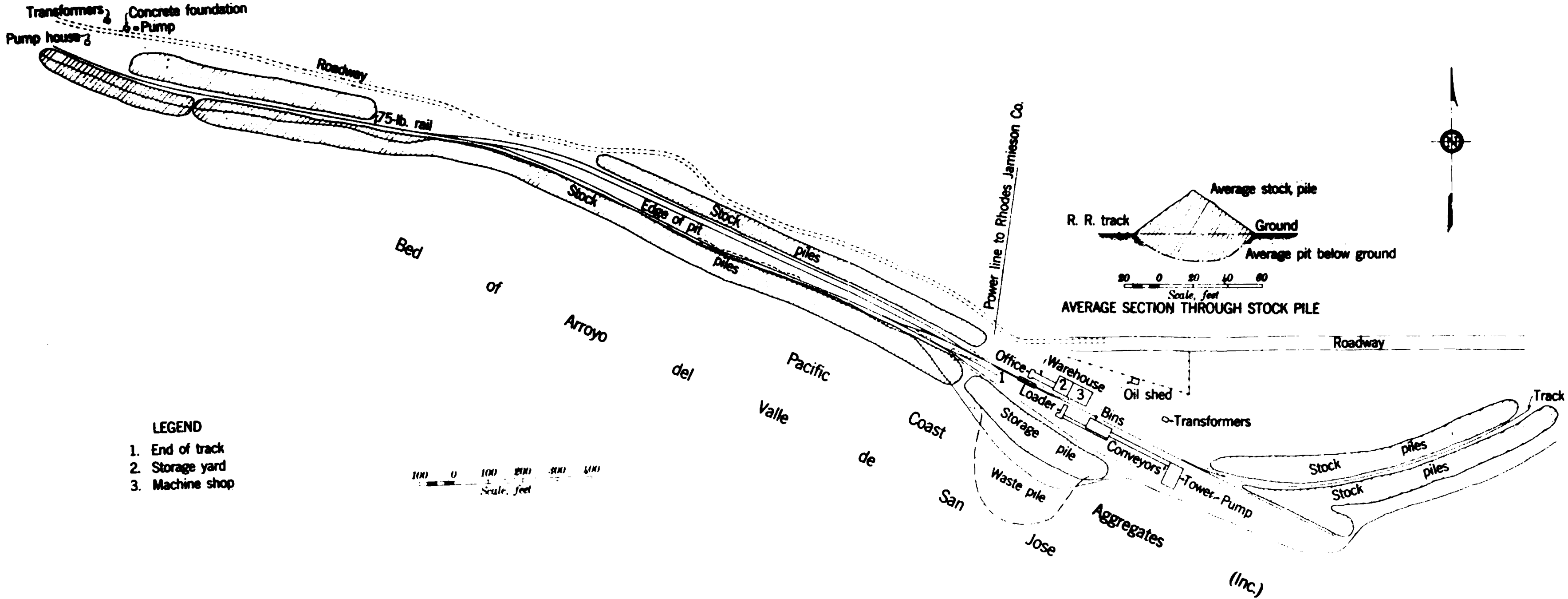


Figure 10.–Storage plan

The disk crusher is the standard spring-head type. A 40-hp., 900-r.p.m. motor drives the main shaft and a 30-hp., 600-r.p.m. motor drives the eccentric. Fourteen-inch, 8-ply belts are used on both drives. The conveyor taking the discharge from both these crushers at ground level is equipped with a 5-ply, 20-inch belt of 32-ounce duck and with 3/16 and 1/16 inch covers. The length of this conveyor between centers is about 170 feet; the inclination is 18°. It is driven at the head pulley by a 25-hp., 1,200-r.p.m. motor belted to an open-type, spur-gear speed reducer operating the conveyor at 250 feet per minute.

This conveyor carries the product of the crushers back to the crushed-rock screens. By these means the plant is enabled to produce aggregates to meet any reasonable specification.

The main bins are equipped, on one side, with quadrant gates and chutes for direct loading into cars which are spotted on the adjacent loading track. On the opposite side similar gates and chutes are so located that a 30-inch mix conveyor belt may be loaded with a stated percentage of several sizes of aggregates to meet the special requirements of specification mixes. The gates are adjustable to wide differences and can thus meet almost any requirement.

The company maintains a testing department at this plant and has a competent man in charge who samples and tests every car of specification material. One copy of his report goes to the customer and one to the operating manager.

STORAGE

Ground storage of commercial sizes of aggregates totaling about 250,000 tons is carried at this plant. The method of transferring this material into and out of storage by means of locomotive cranes and clamshell buckets with 1 1/4 and 1 1/2 cubic yard capacity has been found to be the most convenient and least expensive method.

Formerly steam cranes were used entirely but Diesel cranes recently installed have demonstrated their superiority by effecting a distinct saving in the cost of operation. Various types of storage systems used at other plants of the company lack the flexibility of crane storage and have proved more costly. Inasmuch as it is necessary to handle a great volume of material into and out of storage, this part of the plant operation is an important item and has been thoroughly studied with a view to effecting greater economy.

A storage and switching yard (shown in fig. 10) having spur-track facilities for handling 100 carloads per day as well as a supply of "empties" is connected with the Southern Pacific Railroad Co.'s main tracks at Eliot Station.

To switch cars in the yard it has been found advisable to employ a regular switching locomotive rather than to use the locomotive cranes, and a 20-ton gas locomotive is used for this purpose.

POWER

The plant is operated by electric power furnished by the Pacific Gas & Electric Co. at 440 volts and most machines are individually driven by suitable motors. The connected power, including that required by the electric shovel and the pumps, totals 1,150 horsepower.

The average cost per kilowatt-hour at this and the company's other plants is variable inasmuch as invoices are based on measured maximum demand. For demands of 500 to 999 hp. the rate is as follows:

Horsepower connected load or measured maximum demand	First 50 kw.h. per hp.	Next 50 kw.h. per hp.	Next 150 kw.h. per hp.	All over 250 kw.h. per hp.
500 - 999 hp.	1.9¢	1.2¢	0.8¢	0.6¢

An average month of 700-hp. maximum demand and an energy consumption of 100,000 kw.h. would be billed as follows:

700 hp. x 50 =	35,000 kw.h.	at 1.9¢	= $665.00
700 hp. x 50 =	35,000	do. 1.2¢	= 420.00
Balance	30,000	do. 0.8¢	= 240.00
	100,000	Total	1,325.00 or 1.325¢ average per kilowatt-hour

In months, however, when demand is around the 700-hp. average but energy consumption below the 100,000-kw.h. average, most of the power would be billed in the first price bracket at 1.9 cents per kilowatt-hour and the average cost per kilowatt-hour would be somewhat higher.

A 150-ton track scale with type-registering beam in the office building and in charge of the shipping clerk is part of the plant equipment. In addition to the office building a supply-stock warehouse, a fenced storage yard for large equipment, and a machine and blacksmith shop are also provided.

The capacity of the plant is 300 tons per hour of finished material.

WATER SUPPLY

Water is supplied by two multistage deep-well pumps working in drilled and cased wells about 250 feet deep and each furnishing about 1,500 gallons per minute. A third pump returns water from a settling pond which receives all the overflow from the settling tanks, washers, and screens and enables the mill to use over and over the water supplied by the wells.

The pumps used for furnishing water to the plant are described as follows:

1. About 3,000 feet northward from the plant there is a 12-inch, multistage, deep-well turbine pump with a capacity of 1,000 gallons per minute at 1,800 r.p.m. This pump is directly connected to a vertical 100-hp., 440-volt motor with a full-load speed of 1,740 r.p.m. The hydraulic head is 100 feet and the friction head about 3.25 feet per 1,000 feet of pipe, or about 10 feet. The discharge head is 20 feet, making a total head of 130 feet. All pipe is 12 inches in diameter and is made of 14-gage iron. It has riveted slip joints and is asphalt dipped.
2. About 2,500 feet westward from the plant a 10-inch pump of similar capacity and design is directly connected to a vertical 100-hp., 440-volt motor with a full-load speed of 1,160 r.p.m. The hydraulic head is 100 feet, the friction head 8 feet, and the discharge head 15 feet, making a total head of 123 feet.
3. About 300 feet southeastward from the plant at the settling pond a 6-inch, split-casing, horizontal, centrifugal pump is directly connected by flexible coupling to a 60-hp., 2,200-volt, 1,740-r.p.m. motor. The capacity of this pump is 1,300 gallons per minute against a 125-foot head. The friction head in the 8-inch pipe discharging to the plant is about 12 feet.

These three pumps may be run simultaneously or separately as necessity dictates, and they provide an ample water supply for the plant.

ORGANIZATION

The plant is operated by a resident superintendent who is in charge of all production work and who is responsible to the operating manager in charge of all plants. Details of the organization are shown in Figure 11.

The main office of the company is located in San Francisco where all business, including sales, purchases, and engineering, is transacted. Shipping orders are transmitted by telephone from the city office to the plant, and all supplies are requisitioned on standard forms mailed daily by the plant storekeeper to the purchasing department at the general office.

The operation of this plant ordinarily requires 30 men, who usually work a 10-hour shift although occasional fluctuations in demand may reduce the shift to 8 hours or increase it to 12 hours.

The average tonnage handled varies considerably from time to time because of the fluctuating demands for crushed rock, gravel sizes, and sand. The tendency lately has been toward an increase in crushed-rock production, particularly of closely sized fines - 3/4 inch and under.

If the screen analysis of pit-run material is taken as the basis of production-split the distribution in the plant becomes as follows:

Average duty per plant unit

Unit	Per cent of total feed handled	Tons per hour
No. 1 conveyor	100	300
Scalping screen	100	300
Primary crushers	20 - 25	60 - 75
Reciprocating washer	75 - 80	225 - 240
No. 2 conveyor to gravel screens	75 - 80	225 - 240
Crushed-rock elevator	20 - 25	60 - 75
Crushed-rock screens (includes crushed-gravel rejects)	Up to 33-1/3	Up to 100
No. 1 gravel screen	75 - 80	225 - 240
Two sand wheels, each	12½ - 15	75 - 90
Asphalt-sand drag	4 - 6-2/3	12 - 20
Fine-gravel screens	25 - 35	75 - 105
Reduction crusher and rolls	Up to 16-2/3	Up to 50

The cost figures developed in the following tabulations have been so segregated that the itemized expense for each separate operation and sub-operation may be read directly. The total expense is segregated to show subtotals for operating and maintenance in Table 4. These costs do not represent total production costs but direct local expense only.

As operations during recent years are not representative of normal conditions in the industry, costs during 1927 are given in the tabulations.

	Tons
Total tonnage produced in 1927	645,000
Total shipments	582,654
Average hourly production	159

	Hours
Total operating time	4,590
Total lost time	530

Total shipments were 90.4 per cent of total production. Lost time amounted to 11.5 per cent of operating time.

Table 1.- Operating costs per dry ton of sand and gravel mined

Name of pit: Eliot. Period covered: Year of 1927.
Total sand and gravel loaded during period: 645,000 short tons.

	Labor	Supervision	Power	Fuel	Supplies	Total
Shovel	$0.0158	-	$0.0088	-	$0.0099	$0.0345
Transportation	.0068	-	-	$0.0017	.0023	.0108
Plant	.0398	-	.0149	-	.0247	.0794
Storage	.0386	-	.0013	.0097	.0066	.0562
Superintendence	-	$0.0157	-	-	-	.0157
Miscellaneous	.0018	-	.0004	-	.0029	.0051
Total	0.1028	0.0157	0.0254	0.0114	0.0464	0.2017
Insurance	-	-	-	-	-	.0042
Depreciation	-	-	-	-	-	.0142
						0.2201

Table 2.- Labor, power, and oil used per ton of material produced

Name of plant: Eliot. Period covered: Year of 1927.
Material loaded during period:
Overburden..........None
Sand and gravel..........645,000 tons (weight per cubic yard, 2,700 pounds)

	Mining	Plant	Other	Total
Man-hours of labor per ton of sand and gravel produced	0.020	0.0625	0.081	0.1635
Kilowatt-hours of power per ton of sand and gravel produced:	-	-	-	1.94
Shovels	.67	-	-	-
Pumping	-	.34	-	-
Crushing	-	.26	-	-
Elevating, conveying, and screening	-	.47	-	-
Washing	-	.05	-	-
Storage	-	.10	-	-
Shops	-	.03	-	-
Lighting	-	.02	-	-
Barrels of oil used per ton:				
Storage	-	-	.01	-

Table 3.- Detailed average shovel costs, direct operation

Name of plant: Eliot.
Type of equipment: Electric shovel.
Overburden loaded: None.
Sand and gravel loaded: 645,000 tons.

Period covered: Year of 1927.
Size of dipper: 3 cubic yards

Cost items	Sand and gravel	
	Amount	Cost per ton
Engineers	$7,302.22	$0.0113
Power	5,680.01	.0088
Operating supplies	117.33	.0002
Repair labor	2,889.25	.0045
Repair supplies	6,220.85	.0097
Total repairs	9,110.10	.0142
Total shovel operation	22,209.66	.0345

Table 4.- Direct local expense

	Operating cost per ton								Maintenance cost per ton			
	Labor	Supplies	Electric power	Fuel	Other expense	Insurance and taxes	Depreciation	Operating totals	Labor	Material and parts	Maintenance totals	Cost per ton, totals
Excavation:												
Dinkey	$0.0030	$0.0002	—	$0.0017	—	—	—	$0.0049	$0.0002	$0.0001	$0.0003	$0.0052
Cars	—	—	-	—	—	—	—	—	.0001	.0000	.0001	.0001
Shovel and track	.0148	.0020	$0.0088	-	-	—	—	.0256	.0045	.0099	.0144	.0400
Crushing:	.0239	.0020	.0149	—	-	—	—	.0408	.0159	.0227	.0386	.0794
Loading and Storage:												
Bunkers	.0078	—	.0013	-	—	—	—	.0091	—	-	—	.0091
Crane	.0193	.0006	—	.0079	—	—	—	.0278	.0024	.0037	.0061	.0339
Locomotives	.0056	.0001	—	.0018	—	—	—	.0075	.0008	.0008	.0016	.0091
Tracks	—	—	—	—	—	—	—	—	.0027	.0014	.0041	.0041
General Expense:												
Sup't and office	.0135	—	-	-	$0.0020	-	—	.0155	—	-	-	.0155
Auto. expense	-	.0002	-	-	-	$0.0001	$0.0003	.0006	-	-	—	.0006
Water and air	—	-	.0004	-	-	—	—	.0004	.0001	—	.0001	.0005
Small tools	—	-	—	—	-	—	-	—	—	.0007	.0007	.0007
Tractors and trucks	.0015	.0003	—	—	.0001	.0001	.0002	.0022	.0001	-	.0001	.0023
Roads and grounds	—	—	-	—	—	—	—	-	.0002	-	.0002	.0002
Unsegregated charges	.0001	.0005	-	-	.0006	.0040	.0137	.0189	-	.0005	.0005	.0194
Totals	0.0895	0.0059	0.0254	0.0114	0.0027	0.0042	0.0142	0.1533	0.0270	0.0398	0.0668	0.2201

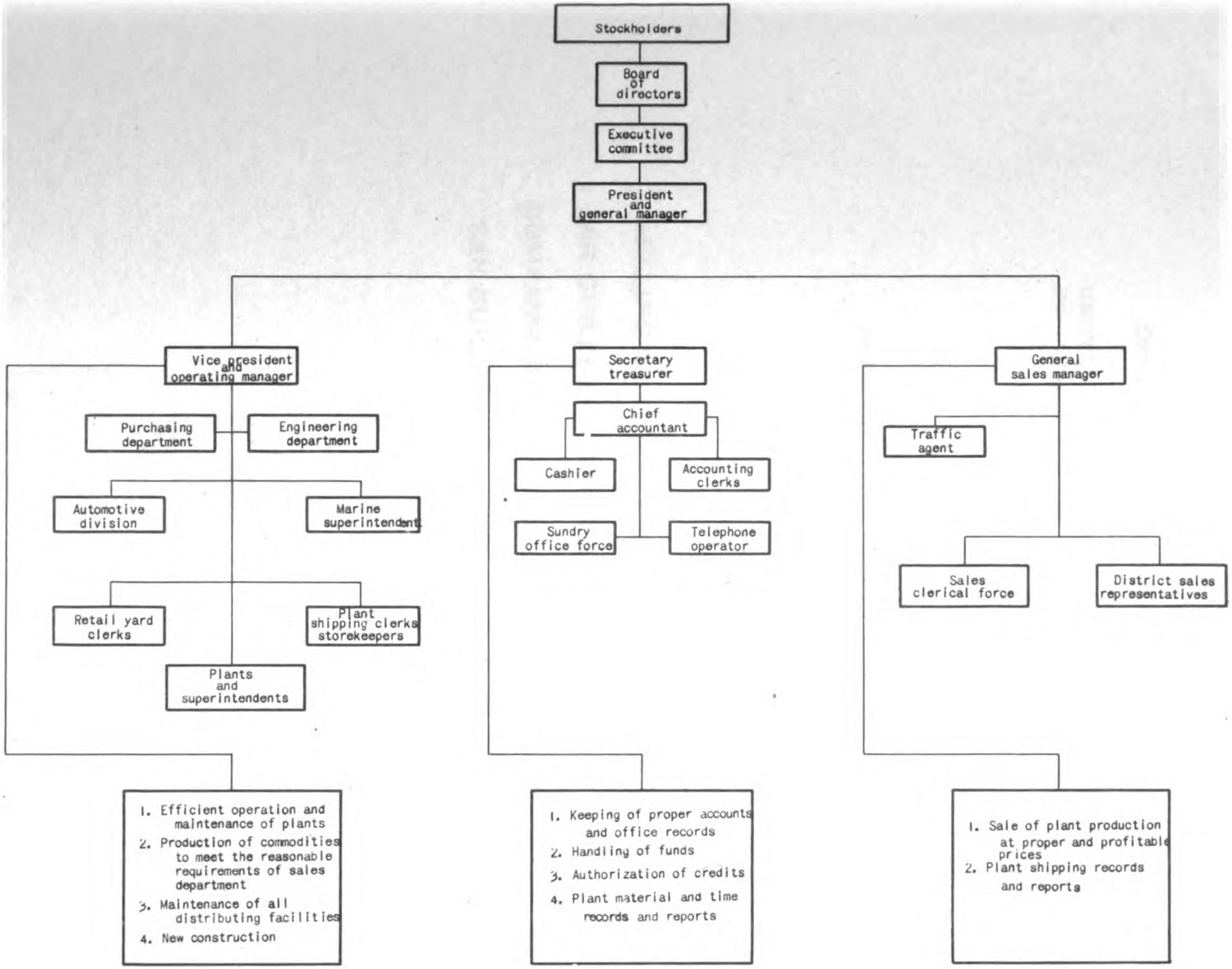

Stockholders
Board of directors
Executive committee
President and general manager
Vice president and operating manager
Purchasing department
Engineering department
Automotive division
Marine superintendent
Retail yard clerks
Plant shipping clerks storekeepers
Plants and superintendents
1. Efficient operation and maintenance of plants
2. Production of commodities to meet the reasonable requirements of sales department
3. Maintenance of all distributing facilities
4. New construction
Secretary treasurer
Chief accountant
Cashier
Accounting clerks
Sundry office force
Telephone operator
1. Keeping of proper accounts and office records
2. Handling of funds
3. Authorization of credits
4. Plant material and time records and reports
General sales manager
Traffic agent
Sales clerical force
District sales representatives
1. Sale of plant production at proper and profitable prices
2. Plant shipping records and reports

Figure 11.- Organization chart